DOCUMENT RESUME

ED 191 709 SE 031 933

TITLE It's A Metric World.
INSTITUTION Alabama State Dept. of Education, Montgomery. Div. of Instructional Services.
PUB DATE 76
NOTE 26p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Decimal Fractions; Elementary Education; *Elementary School Mathematics; Enrichment Activities; Instructional Materials; Learning Activities; *Mathematical Concepts; Mathematics Curriculum; *Mathematics Education; *Mathematics Instruction; Mathematics Materials; Measurement; *Metric System; Resource Materials; Teaching Methods

ABSTRACT

Topics covered in the first part of this document include eight advantages of the metric system; a summary of metric instruction; the International System of Units (SI) style and usage; metric decimal tables; the metric system; and conversion tables. An alphabetized list of organizations which market metric materials for educators is provided with a key designating types of instructional aids. The second part of this paper, entitled Prepare for a Metric Alabama, presents distances in kilometers around Alabama; a brief history of the metric system; suggested activities and teaching aids for elementary classes; and a table of selected metric-English conversions. Although prepared for elementary teachers K-5, these materials could be adapted to junior and senior high use by modifying activities, problem applications, and vocabulary. (MP)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

AR 000 050

ED191709

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Dr. Wayne Teague

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE 031 933

State Department of Education
Division of Instruction
Basic Sciences Section

COMMONLY LISTED ADVANTAGES OF THE METRIC SYSTEM

1. The metric system is a simple, logically planned system. Its decimal basis conforms to our numeration system and to our monetary system.

2. The meter, which establishes the basis for the entire system, is always reproducible from natural phenomena and, therefore, is immune to destruction; it is international in character and well suited for precision work. The coordination of measures of length, area, volume and mass, combined with decimalization, facilitates computations.

3. Once the system of prefixes has been learned, the uniformity in names for all types of measures makes for greater simplicity and ease in changing to more convenient-sized units for specific purposes.

4. Although many of the claims of the amount of time that can be saved in learning fractions are probably exaggerated, less competence in the manipulation of common fractions will be required of many students, and some restructuring of time spent on such computation might be profitably accomplished. Ultimately, when only the metric system will be taught, time can be saved in learning of conversion units (1 ft. = 12 in., 1 yd. = 3 ft., 1 rd. = 16-1/2 ft., 1 mi. = 5280 ft., and so on) and in the learning of a second new system for use in science classes.

5. For ordinary work, familiarity with the meter, gram, and liter will be sufficient. However, for the engineer and the scientist, the new International System of Units (SI), based on the metric units, eliminates conversion problems in calculations with derived units. That is, although power is universally defined as work per unit time, it is variously expressed in Btu/sec, therms/day, ft-lb/hr, horsepower, calories/sec, watts, and so on. The use of two different terms, kilogram and newton, for units of mass and force respectively, eliminates much of the confusion students have concerning these concepts.

6. Greater participation of the United States in the setting of international engineering standards will be possible since the metric system is the universal language of measure. Exports, foreign trade, and competition with other nations will depend more and more on production under metric standards.

7. A common measurement language that is used by scientists, engineers, and industrial workers will improve communication and reduce barriers between different sectors of society.

8. The necessity of conversion will offer fringe benefits. During the adjustment to the new measurements, there will be opportunities to eliminate superfluous varieties in sizes of products, parts, and containers, and to make additional worth-while changes in engineering standards, construction codes, and products design.

AUG 7 1980

The ABC and XYZ of Metric Instruction (KISS)

A. The U.S.A. has gone metric and will adopt the International System of Units (SI).

There are three classes of units in SI; base units, supplementary units, and derived units.

The base units and symbols are:

1. length - meter, m
2. mass - kilogram, kg
3. time - second, s
4. electric current - ampere, A
5. thermodynamic temperature - kelvin, K
6. amount of substance - mole, mol
7. luminous intensity - candela, cd

The supplementary units and symbols are:

1. plane angular measure - radian, rad
2. solid angular measure - steradian, sr

The derived units are too numerous to list here but from the above base units (7) and supplementary units (2) all other measurement units are derived logically.

B. For elementary or introductory teaching there is a fourth class of units which can be called the teaching units. These units and symbols are:

1. length - meter, m
2. capacity *- liter, L
3. mass * - gram, g

* Capacity and mass are the proper terms for what we sometimes refer to as volume and weight respectively.

The prefixes and symbols are:

1000 times the base unit - kilo, k
100 times the base unit - hecto, h
10 times the base unit - deka, da
the base unit - meter, liter, or gram
0.1 times the base unit - deci, d
0.01 times the base unit - centi, c
0.001 times the base unit - milli, m

There are prefixes for larger multiples and smaller submultiples but the foregoing are enough for initial instruction.

4

If the decimal concept has not been taught, then 1/10, 1/100, and 1/1000 may be used. However, the decimal is preferred. The decimal system, our monetary system, and the metric system are comparable and knowledge of one facilitates learning of the others.

The everyday unit of temperature and its symbol is degree Celsius, $^{\circ}C$.

The freezing point of water is $0^{\circ}C$.
The boiling point of water is $100^{\circ}C$.

Of the units mentioned so far only one is capitalized - Celsius - and only four symbols are capitals - A for ampere, K for kelvin, C for Celsius, and L for liter. Indiscriminate use of upper and lower case letters will cause incorrect notations and calculation errors.

C. Use the students' present knowledge of measurement as a frame of reference and teach approximate comparison of customary and metric units.

1" ≈ 2.5 cm	1 cm ≈ 0.4"
1 yd. ≈ 0.9 m	1 m ≈ 39"
1 mile ≈ 1.6 km	1 km ≈ 0.6 mile
1# ≈ 450 g	1 kg ≈ 2.2#
1 qt. ≈ 0.95 liter	1 liter ≈ 1.06 qts.

At upper elementary levels the students should learn the interrelatedness of meter, liter, and gram. Under controlled laboratory conditions 1 cubic decimeter has a capacity of 1 liter of water which has a mass of 1 kilogram. This relationship also can be stated as:

$1\ dm^3 = 1\ L = 1\ kg$
$1\ cm^3 = 1\ mL = 1\ g$ or
$1\ m^3 = 1\ kL\ (1000\ L) = 1\ t\ (1000\ kg = 1$ metric ton)

The X, Y, and Z of metric instruction:

X - Teach terminology first: meter, liter, gram, with prefixes, and $^{\circ}$Celsius.
Y - Teach estimation then measurement of familiar objects in length, weight, and volume, and compare Celsius and Fahrenheit scales.
Z - Review periodically but do not overdo metric in the beginning.

KEEP IT SIMPLE, STUPID

Apologies for the KISS but this was standard advice for Army instructors and it applies to metric instruction also.

SI STYLE AND USAGE

A few basic rules for correct usage of SI units, symbols, and numbers:

1. Spelling and Capitalization

Avoid capitalization of unit names (except Celsius) unless they start a sentence. Listings should be lowercase.

Example:	Correct The following are the seven SI base units:	Incorrect The following are the seven SI base units:
	meter	Meter
	kilogram	Kilogram
	second	Second
	ampere	Ampere
	kelvin	Kelvin
	mole	Mole
	candela	Candela

2. Correct use of uppercase and lowercase letters is imperative to avoid misinterpretation of a symbol. Unit symbols derived from proper names are capitalized and some prefixes are capitalized to distinguish from other lowercase use of the letter.

Some metric units and prefixes with symbols using same letter:

Unit	Symbol	Prefix	Symbol
metric ton	t	tera	T
gram	g	giga	G
meter	m	mega	M
		milli	m
kelvin	K	kilo	k
degree Celsius	°C	centi	c
coulomb	C		
hour	h	hecto	h
newton	N	nano	n

Note that there are several instances of upper and lowercase letters having very different meanings. Teach students to make distinguishable upper and lowercase alphabet characters, and practice the same yourself.

Symbols

1. Symbols are not punctuated with periods except at the end of a sentence.

   Example: kg NOT kg. or k.g.

2. Symbols for units do not have plural forms.

   Example: 10 kg (10 kilograms) NOT 10 kgs (10 kilograms)

3. A space is left between the number and the unit symbol; the only exception to this rule is for the location of the symbols used with plane angles and degree Celsius.

   Example: 25 mm, 27 C, and 90 NOT 25mm, 27 C, and 90

4. A capital L should be used as the symbol for liter to avoid confusing it with the numeral one (1).

5. Exponential index numbers are used with symbols to signify "square" or "cubic" measure.

   Example: cm (square centimeter) NOT sq.cm. (square centimeter)
   cm (cubic centimeter) NOT c.c. (cubic centimeter)

6. The symbol for "per" is a slash "/"

   Example: Write 90 km/h or NOT 90 k.p.h. or 90 km per h
   90 kilometers per hour NOT 90 kilometers/hour

Numbers

7. In recording measurements decimal notation should be used instead of common fractions and when writing numbers less than one a zero is placed in front of the decimal point.

   Example: 0.5 NOT 1/2
   0.25 NOT .25

Grouping of Numbers:

8. A space rather than a comma is preferred for indicating how numbers are grouped.

   Example: 27 000 NOT 27,000

In numbers of four digits no space is recommended.

   Example: 5000 NOT 5,000 OR 5 000

METRIC DECIMAL TABLE

CIMAL	THOUSANDS	HUNDREDS	TENS	ONES	TENTHS	HUNDREDTHS	THOUSANDTHS
cimal ace Value	1000 thousands	100 hundreds	10 tens	1 ones	0.1 tenths	0.01 hundredths	0.001 thousandths
S. Money	$1000 bills	$100 bills	$10 bills	$1 dollar	$.10 dime	$.01 cent	$.001 mill
tric ngth	kilometer km	hectometer hm	dekameter dam	meter m	decimeter dm	centimeter cm	millimeter mm
tric pacity	kiloliter kL	hectoliter hL	dekaliter daL	liter L	deciliter dL	centiliter cL	milliliter mL
tric ss	kilogram kg	hectogram hg	dekagram dag	gram g	decigram dg	centigram cg	milligram mg

The powers of 10 have both names and symbols and are referred to as multiples and submultiples.

	Prefix	Symbol
$1\,000\,000 = 10^6$	mega	M
$1\,000 = 10^3$	kilo	k
$100 = 10^2$	hecto	h
$10 = 10^1$	deka	da
$0.1 = 10^{-1}$	deci	d
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000\,001 = 10^{-6}$	micro	μ

9

8

THE METRIC SYSTEM

LINEAR MEASURE

10 millimeters	.....	1 centimeter
10 centimeters	.....	1 decimeter
10 decimeters	.....	1 meter
10 meters	.....	1 dekameter
10 dekameters	.....	1 hectometer
10 hectometers	.....	1 kilometer

SQUARE MEASURE

100 square millimeters	.....	1 square centimeter
100 square centimeters	.....	1 square decimeter
100 square decimeters	.....	1 square meter
100 square meters	.....	1 square dekameter
100 square dekameters	.....	1 square hectometer
100 square hectometers	.....	1 square kilometer

CUBIC MEASURE

1000 cubic millimeters	.....	1 cubic centimeter
1000 cubic centimeters	.....	1 cubic decimeter
1000 cubic decimeters	.....	1 cubic meter

LIQUID MEASURE

10 milliliters	.....	1 centiliter
10 centiliters	.....	1 deciliter
10 deciliters	.....	1 liter
10 liters	.....	1 dekaliter
10 dekaliters	.....	1 hectoliter
10 hectoliters	.....	1 kiloliter

MASS

10 milligrams	.....	1 centigram
10 centigrams	.....	1 decigram
10 decigrams	.....	1 gram
10 grams	.....	1 dekagram
10 dekagrams	.....	1 hectogram
10 hectograms	.....	1 kilogram
1000 kilograms	.....	1 metric ton

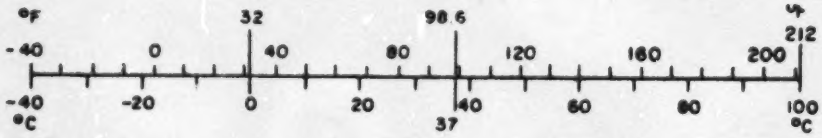
U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

NBS Letter Circular 1051
July 1973

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
		VOLUME		
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



*1 in = 2.54 cm (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10: 286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares(10 000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1000 kg)	1.1	short tons	
	VOLUME			
mL	milliliters	0.03	fluid ounces	fl oz
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5(then add 32)	Fahrenheit temperature	°F

This Letter Circular (LC1051) provides conversion factors for going from the more common customary units to metric units and vice versa. It may be reproduced freely. LC1051 is based on NBS Special Publication 365 (Revised Nov. 1972), "Metric Conversion Card", available by purchase as a wallet-size plasticized card from the U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402. Price 20 cents domestic postpaid, or 10 cents GPO Bookstore. Stock Number 0303–0168. Catalog No. C13.10: 365/2. (25 percent discount on orders of 100 or more copies).

ORGANIZATIONS MARKETING METRIC MATERIALS FOR EDUCATORS

KEY: (B) Books or Pamphlets
(F) Films or Filmstrips
(K) Kits
(P) Posters
(I) Other Instructional Aids

(I) A. Balla & Co.
Post Office Box 24,200
Fort Lauderdale, FL 33308

(B) Activity Resources Company, Inc.
Box 4875
Hayward, CA 94545

(B) Allyn and Bacon, Inc.
470 Atlantic Avenue
Boston, MA 02210

(B) American Association of School Librarians
50 East Huron Street
Chicago, IL 60611

(B,P) American National Standards Institute
1430 Broadway
New York, NY 10018

(B) Behavioral Research Laboratory
Box 577
Palo Alto, CA 94302

(F) BFA Educational Media
2211 Michigan Avenue
Santa Monica, CA 90404

(I) Central Instrument Company
900 Riverside Drive
New York, NY 10032

(B) Channing L. Bete Company, Inc.
45 Federal Street
Greenfield, MA 01301

(B) Charles E. Merrill Publishing Company
1300 Alum Creek Drive
Columbus, OH 43216

(I) Compu-Data Services, Inc.
16 Sherman Street, P.O. Box 471
Wayne, NJ 07470

(B,F) Coronet Films
65 East South Water Street
Chicago, IL 60601

(I) Creative Publications
P.O. Box 10328
Palo Alto, CA 94303

(I) C-Thru Ruler Company
6 Britton Drive
Bloomfield, CT 06002

(I) Cuisenaire Company of America
12 Church Street
New Rochelle, NY 10805

(I) Dick Blick Co.
P.O. Box 1267
Galesburg, IL 61401

(B,P) Dominie Pty Ltd.
8 Cross Street
Brookvale, Australia 2100

(K) Edmund Scientific Co.
380 Edscorp Building
Barrington, NJ 08007

(I) Educational Teaching Aids
159 West Kinzie Street
Chicago, IL 60610

(K) Encyclopedia Britannica Education Corp.
425 North Michigan Avenue
Chicago, IL 60611

(F) Eye Gate House, Inc.
146-01 Archer Avenue
Jamaica, NY 11435

(B,I) Grolier Educational Corporation
845 Third Avenue
New York, NY 10022

(B,I) Houghton Mifflin Company
110 Tremont Street
Boston, MA 02107

(F,I) Ideal School Supply Company
11000 South Lavergne Avenue
Oak Lawn, IL 60453

(B,P) Instructor Publications, Inc. (The)
Instructor Park
Dansville, NY 14437

(I) International Business Machines Corp.
Old Orchard Road
Armonk, NY 10504

(K) International Tutors
Department A, 22303 Devonshire
Chatsworth, CA 91311

(P) Jem Innovations
4568 East 45th Street
Tulsa, OK 74135

(I) John Colburn Associates, Inc.
P.O. Box 187
Lake Bluff, IL 60044

(B) John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10016

(B) Laidlaw Brothers
Thatcher & Madison
River Forest, IL 60305

(K) Larry Harkness Company
115 N. Princeton Avenue
Villa Park, IL 60181

(I) Leicestershire Learning Systems
Box 335
New Gloucester, ME 04260

(F) Library Filmstrips Center
3033 Aloma
Wichita, KS 67211

(I) MacLean-Hunter Learning Materials Co.
481 University Avenue
Toronto 101, Ontario, Canada (Can.only)

(B,F) McGraw-Hill, Inc.
1221 Avenue of the Americas
New York, NY 10020

(I) Math Shop
5 Bridge Street
Watertown, MA 02172

(I) Metric Aids Limited
75 Horner Avenue
Toronton530, Ontario, Canada

(B) Metric Association, Inc.
Sugarloaf Star Route
Boulder, CO 80302

(I) Metrix Corporation
P.O. Box 19101
Orlando, FL 32814

(B) Midwest Publications Co., Inc.
P.O. Box 129
Troy, MI 48084

(I) Mind/Matter Corp.
P.O. Box 345
Danbury, CT 06810

(I) Moyer Vico Limited
25 Milvan Drive
Weston, Ontario, Canada M9L 1Z1 (Can.only)

(B) National Aeronautics and Space Administration
Marshall Space Flight Center, AL 35812

(B,I, P) National Council of Teachers of Mathematics
1906 Association Drive
Reston, VA 22091

(B) National Education Association
American Education Week
P.O. Box 327
Hyattsville, MD 20781

(I,P) National Microfilm Association
Suite 1101
8728 Colesville Road
Silver Spring, MD 20910

(B,K) National Science Teachers Association
1201 16th Street, N.W.
Washington, D.C. 20036

(B) National Textbook Company
8259 Niles Center Road
Skokie, IL 60076

(B) National Tool, Die & Precision Machining Association
9300 Livingston Road
Washington, D.C. 20022

(F) NBC Educational Enterprises
30 Rockefeller Plaza
New York, NY 10020

(F,I) Pathescope Educational Films, Inc.
71 Weyman Avenue
New Rochelle, NY 10802

(I) Pickett Industries
P.O. Box 1515
Santa Barbara, CA 93102

(I,P) Polymetric Services
4600 Brewster Drive
Tarzana, CA 91356

(B) Random House
The School Division
Westminster, MD 21157

(I) Realty Facts
P.O. Drawer 449
Warwick, NY 10990

(I) Robie Sales Company
2755 Woodshire Drive
Hollywood, CA 90068

(I) Rowsey Enterprises
P.O. Box 666
Friendswood, TX 77546

(I,P) Sargent-Welch Scientific
7300 N. Linder Avenue
Skokie, IL 60076

(I) Selective Educational Equipment, Inc.
3 Bridge Street
Newton, MA 02195

(I) Sigma Scientific, Inc.
P.O. Box 1302
Gainesville, FL 32601

(F) Society for Visual Education, Inc.
1345 Diversy Parkway
Chicago, IL 60614

(I) Spectrum Educational Supplies Limited
9 Dohme Avenue
Toronto, Ontario, Canada M4B 1Y7

(B) Sterling Publishing Company, Inc.
419 Park Avenue, South
New York, NY 10016

(B,I K) Swani Publishing Company
Box 248
Roscoe, IL 61073

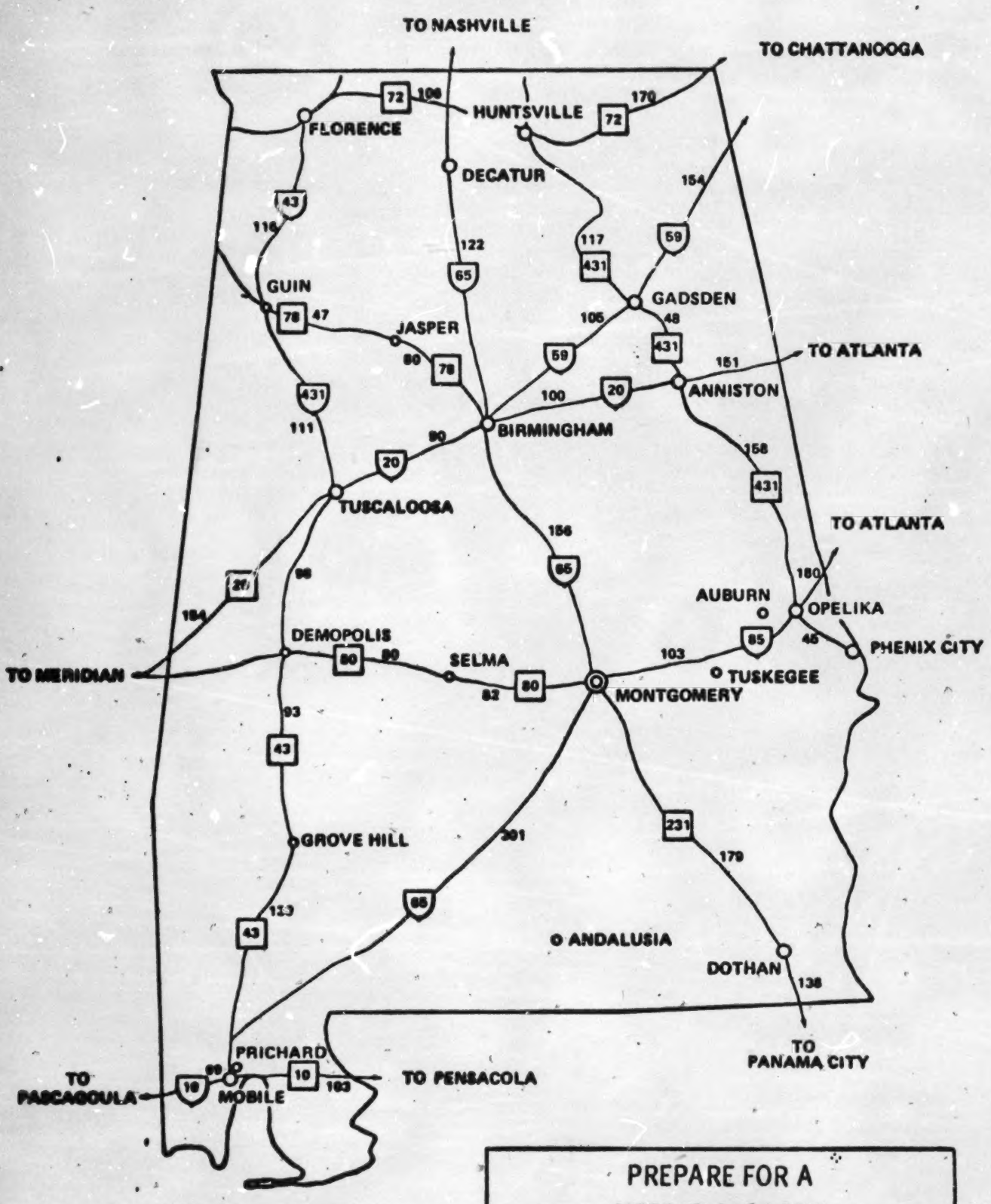
(I) Teach'em Inc.
625 North Michigan Avenue
Chicago, IL 60611

(I,P) Union Carbide Corporation
Educational Aids Department
P.O. Box 363-B
Tuxedo, NY 10987

(B,I, P) U.S. Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

(1BF) OHAUS Scale Corporation
29 Hanover Road
Florham Park, New Jersey 07932

DISTANCES IN KILOMETERS



PREPARE FOR A
METRIC ALABAMA

FOREWORD

The metric system is a logical system of measurement with most of the measurement standards based on natural phenomena. The conversion factors within the system are powers of 10. The metric system is now used by over 90% of the nations of the world. In 1965 the British announced their move to metrics. In 1970 Australia and Canada announced that they would change to the metric system. In a world moving more and more toward the metric system, the United States must use metrics in scientific work and trade in order to collaborate with other nations.

The metric system is not new to our schools. It has been a minor part of every student's education. However, with the increased use of the metric system almost a certainty, our schools must provide further instruction in the metric measurement system. The instruction in the metric system should not, however, progress much beyond the common metric units used in everyday life as they are introduced into society. Instruction in the metric system should not lead to mental gymnastics with a great deal of memorizing and conversion between the English and metric measurement systems.

For a period of time both the metric and English systems of measurement will be used. Both systems should be taught in this transition period. However, conversion from one system to the other should be treated casually and quite informally. Pupils should develop a feeling for comparison between units - a meter is a little longer than a yard and a liter is a little larger than a quart.

This outline has been prepared to provide elementary teachers with some information about the metric system and some suggestions for teaching it. It is further suggested that junior and senior high school teachers use the format but select activities, problem applications, and vocabulary that are more appropriate for the grade level.

The history and suggested activities that follow are the same as those used in New York State. This is not an officially adopted scope and sequence but should be of value until such time as the metric system is officially incorporated into the State Course of Study.

HISTORY

The metric system was developed in France in the latter part of the 18th century when the National Assembly of France, on May 8, 1790 was called upon to create an invariable standard for weights and measures. The French Academy developed a decimal-based system in which the standard unit of length was the metre (which we spell meter), derived from the Greek word metron, meaning "a measure." The meter was to be equal to one ten-millionth of the distance from the north pole to the equator measured along a meridian of the earth near Dunkirk and Barcelona. This system was based on a proposal that Gabriel Mouton made in 1670.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter of water at its maximum density. The unit of fluid capacity, called the "liter," was defined as a cubic decimeter or one thousand cubic centimeters.

As time passed, revisions were made in the metric system and the number of countries adopting it increased. In 1866 the United States Congress made it lawful to use the metric system of weights and measures in any and all business. In 1893 the Secretary of the Treasury of the United States declared that metric standards would be the fundamental weights and measures standards of the United States. Thus, the yard was, and is, legally defined as a fractional part of a meter and the pound as a fractional part of a kilogram, a fact unknown by many.

The Soviet Union's launch of Sputnik in 1957 renewed interest in science and mathematics, and, in 1959, the yard was defined as exactly 0.9144 meter and the avoirdupois pound as 0.45359237 kilogram. In 1960 the meter was defined as 1,650,763.73 wave lengths in vacuum of the orange-red line of the spectrum of Krypton 86. This standard is accurate to 1 part in 100,000,000 and has the advantage of being reproducible in scientific laboratories throughout the world.

THE METRIC SYSTEM

The metric system is a decimal-based system and somewhat parallels the decimal numeration system as shown in the chart

Decimal Numeration		Metric	
thousands		kilo	
hundreds		hecto	
tens		deka	
ones			
	.		.
tenths		deci	
hundredths		centi	
thousandths		milli	

Prefixes assigned to the base units designate powers of 10. Greek derived prefixes are assigned to the multiples and Latin prefixes are assigned to the submultiples.

	Prefix	Length	Volume	Mass
10 x 10 x 10 = 1000	kilo	kilometer (km)	kiloliter	kilogram
10 x 10 = 100	hecto	hectometer (hm)	hectoliter	hectogram
10	deka	dekameter (dam)	dekaliter	dekagram
base unit		meter (m)	liter	gram
1/10	deci	decimeter (dm)	deciliter	decigram
1/10 x 1/10 = 1/100	centi	centimeter (cm)	centiliter	centigram
1/10 x 1/10 x 1/10 = 1/1000	milli	millimeter (mm)	milliliter	milligram

Only the prefixes - milli, centi, deci, and kilo should be stressed in the elementary grades.

The units are interrelated - under standard conditions, one cubic centimeter of water is one milliliter and has a mass of one gram.

In the elementary school the distinction between mass and weight can be mentioned but children should be allowed to use the term "weight" in their work. Mass is a fundamental concept. Like length and time it is one of the basic ideas upon which much else is defined. Mass is sometimes thought of as the amount of material in an object. Weight is the measure of gravitational force on a mass (object) and varies with the location of the object. The weight of an astronaut on the moon is less than his weight on the earth because the force of gravity is less on the moon. He may even be weightless in a space station such as Skylab. However, his mass is the same in all three places. We have been so used to using the term "weight" incorrectly that "weight" will still probably be used for everyday purchases even in cases where the correct term would be "mass."

SUGGESTED ACTIVITIES

TEACHING AIDS

Aids useful for teaching the metric system should be available. Meter sticks and 20- or 30-centimeter rulers graduated only in metric units are desirable. Pan balances with gram weights are useful for studying about mass and containers graduated in metric units are useful for studying volume. Heavy cardboard is helpful in making metric rulers and models of square decimeters, square meters, cubic decimeters, cubic meters, and the like. Many of the colored rods, for example Cusinaire rods, have unit blocks that are cubic centimeters. A Celsius (commonly called centigrade) thermometer should also be available.

Schools having science programs which employ metric measures may find it helpful to coordinate mathematics with science.

KINDERGARTEN

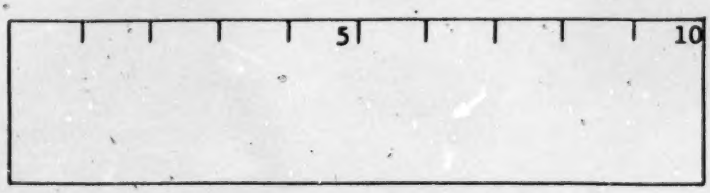
Length, mass, capacity, time, and temperature are the most important variables that can be learned by young children. Introduce metric units of measure such as meter, gram, and liter in a very informal manner. Offer children the opportunity to use metric units in play activities using sand and water. If a child comes in with a new toy, consider the quantitative aspects of it. Find its length, height, weight, and the distance around various parts of the toy.

Practically everything in the classroom may be compared by height, weight, or length. Try to give some point to the activities. For example, how high should the water fountain be? Of course, memorization and exercises calling for conversion from one system of measurement to another are out of place in the primary grades.

GRADE 1

Children need not learn the conversion factors for many years, but they should have a variety of measuring activities using metric units.

Explore counting on a metric ruler.



Have a child measure, with his metric ruler, various objects in the room - his desk, pencil, book, a floor tile.

Comparison should be used to develop an understanding of the basic units. Is a meter about the length of the school building, or about the length of a paper clip, or about the distance that a first grader can reach between his outstretched arms. Is a liter about the equivalent of a quart, or would it fill a bathtub or a swimming pool?

Liter containers should be available along with cups and quarts for comparison.

The pupils can read and record the temperature each day from both a Celsius and a Fahrenheit thermometer.

Graphs are useful tools in working with units of measure. First graders can make and interpret simple charts and graphs. Graphs can be made from daily temperature readings. Or have the children measure the lengths of classroom objects (measurements of the body such as heights or arm lengths can also be used) and write their measurements on a chart on the chalkboard. An exciting comparison to be charted on a graph is the shadow lengths of pupils at different times of the day or year. Any drawing, picture, or diagram should be considered a "graph." Children should not be forced into a particular format, say "bar graph."

GRADE 2

Begin developing relationships between the prefixes, stressing the "tenness" of the system and comparing it to the base 10 numeration system. Reinforce this relationship with appropriate activities. As an example, have the pupil take colored water or sand from a large container and count the number of times he must fill a deciliter graduated cylinder in order to fill a liter container. This will show the child that 10 deciliters is the equivalent of 1 liter.

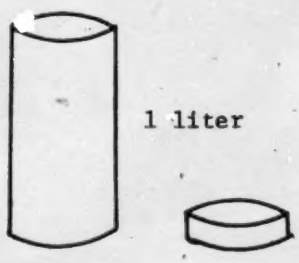
Have the children make meter tapes and measure and label distances around the room. Encourage the pupils to learn the more common prefixes - milli, centi, deci, and kilo.

Introduce the symbols for metric units: mm for millimeter
cm for centimeter
m for meter
km for kilometer

(Note that no periods are used in the abbreviations)

Appropriateness of measuring units should be discussed. To illustrate, the width of a book would be measured in centimeters, the length of a room in meters, and the distance between two cities in kilometers. Speed limits will be given in kilometers per hour.

Likewise, compare milliliter and liter. Have the pupil cite situations that might require a unit of measurement smaller than the milliliter or larger than the liter.



GRADE 3

Practice using and reading the metric ruler to develop measurement skills. Most children find the decimal notation easier to comprehend when they use instruments whose marks they can see. Thus, metric rulers or pan balances are helpful. The fixed points on the Celsius scale (centigrade thermometer) are 0°, the temperature of freezing water, and 100°, the temperature of boiling water at standard sea level pressure.

Learn the relations:

10 millimeters = 1 centimeter
100 millimeters = 1 decimeter
1000 millimeters = 1 meter
10 centimeters = 1 decimeter
100 centimeters = 1 meter
1000 meters = 1 kilometer

Conversion within the metric system is fairly easy. For example, how many centimeters in 28 kilometers?

Answer: 28 x 1000 x 100 cm = 2 800 000 cm

Compare with the English system. How many inches in 28 miles?

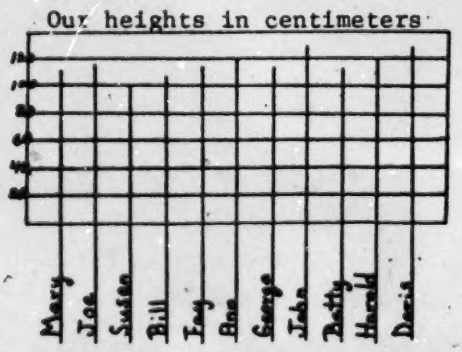
Answer: 28 x 5280 x 12 = 1,774,080 inches

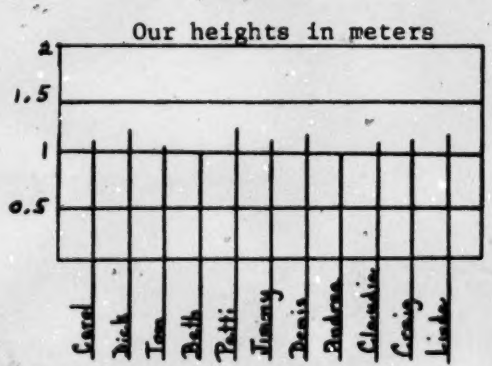
Introduce addition and subtraction with common measures. Example, add: 4 meters, 3 decimeters, 2 centimeters to 2 meters, 3 decimeters, 1 centimeter. Put the answer in terms of centimeters.

Provide plenty of practice for using and reading linear, volume, weight (mass) and temperature metric measures.

Again, graphs can be introduced and used profitably.

Constantly seek interesting examples of metric measures used in the world around us. Track and field games, Olympic contests, and news reports from other countries offer good examples of relevant things that might be discussed with children.





GRADE 4

Continue metric measurement activities.

Learn the relations: 1 millimeter = 1/10 centimeter = 1/1000 meter
1 centimeter = 1/100 meter
1 meter = 1/1000 kilometer

Continue addition and subtraction with common measures.

Examples with regrouping:

6 dm	4 cm	5 mm	compare with:	645
+2 dm	7 cm	7 mm		+277

6 dm	4 cm	5 mm	compare with:	645
-2 dm	7 cm	7 mm		-277

Weights (masses) of 0.5 kg, 1 kg, and 5 kg should be provided, or made, so that pupils may learn to form their own estimations. A #303 can of vegetables is about 0.5 kg. A quart of milk with the carton is about 1 kg. An ordinary building brick has a mass of approximately 2 kg. A gallon of maple syrup or oil base paint is approximately 5 kg. For smaller measurements, an ordinary paper clip has a mass of about 1 gram and a nickel about 5 grams.

Encourage the children to find the mass of a textbook, a paperback, or a large dictionary.

Plot the growth (length or weight) of a young mouse or hamster. Pupils should become familar with the number of millimeters in everyday containers such as soda bottles and milk cartons. Estimation should be a part of every measurement problem.

Continue use of Celsius thermometer.

GRADE 5

Continue with a variety of metric measurement activities. This is an area that lends itself to "hands on" activities and much use can be made of math lab techniques.

The children should by now be familiar with a Celsius thermometer. The temperature range between 0° and 100° is divided into 100 equal parts, called

degrees. Conversion to the Fahrenheit scale is not to be stressed, but examples may be given showing their relation. Example, in 25°F a man might be shoveling snow while in 25° Celsius he might be swimming. The human body temperature is 98.6°F but is 37° Celsius.

Some pupils might wish to try experiments such as finding the temperature of ice water and that of water from the hot water tap. Encourage them to find the average room temperature or the average outdoor temperature for a day or week.

In metric measurement, liquid and dry measure are the same. If 25 liters of grain have a mass of 20 kilograms, what is the mass of 1 liter of grain in kilograms?

The youngsters should also have experience with graduated cylinders which are marked in liters or milliliters.

Introduce the concept of area and develop area measurement intuitively. Limit the work to square centimeters, square decimeters, and square meters. Centimeter graph paper is useful for area study. One activity might be to have the child outline his hand or some other object on the graph paper and estimate the area.

Fifth graders can extend their knowledge of measurement by working with distance in our solar system. Develop a table and use it to demonstrate the planetary distances to the sun and some of the planets. A similar table may be created to show the diameters of the planets.

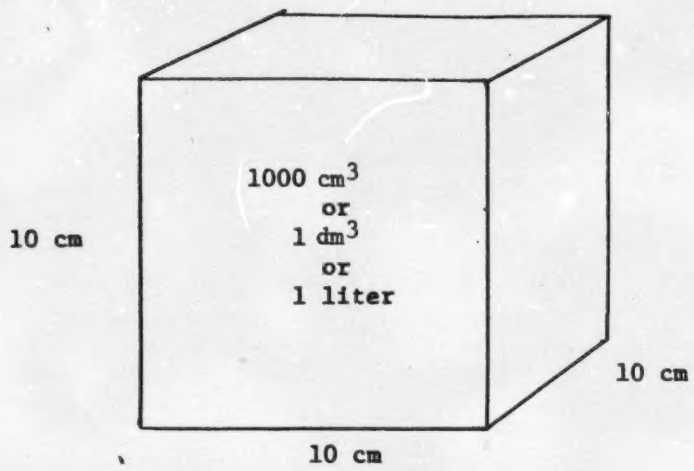
	Distance from Sun	
	Kilometers	Miles
Sun	...	...
Mercury	58 million	36 million
Venus	108 "	67 "
Earth	149 "	93 "
Mars	228 "	142 "
Jupiter	778 "	483 "
Saturn	1430 "	886 "
Uranus	2870 "	1783 "
Neptune	4490 "	2793 "
Pluto	5900 "	3666 "

GRADE 6

Continue metric measure activities to extend understanding and use of metric units.

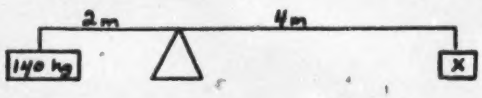
Develop the idea of volume of rectangular solids using objects and pictorializations.

Stress the fact that a liter is one cubic decimeter or 1000 cm^3.



Word problems using volume should be presented at this grade level. Provide practice in adding, subtracting, multiplying and dividing with numbers that are metric measures.

Science education can be integrated with mathematics education very well at this level. Information about pulleys, levers, and inclined planes may be taught as a springboard for future science concepts. Use metric measurements.



If the lever balances, what is the mass of x? Physical experiments with scientific apparatus will create interest and, if calculations are kept simple, the formulas will be shown to work.

Angle measures are the same in the metric system as they are in the English system. There are 360 degrees in a circle. Pupils should be able to recognize and measure acute, obtuse, and right angles.

METRIC-ENGLISH CONVERSIONS?

The prevailing opinion among educators is that conversions from the metric system to the English measurement system and from the English to the metric should be a very small part of metric instruction. Many educators feel that conversion between the two systems should not be included at all. They feel that it is much better for the student to do his measurement thinking within one system. There is really little necessity for conversion between the systems.

If some conversion is desired, either to show relationships between units or for practice with multiplication and division, then conversion factors should be given to the pupils. They should not be required to memorize conversion factors. Estimates should be encouraged before computations.

The following relationships may be used:

1 cm = .39 in. (approximately)
1 m = 3.28 ft. (approximately)
1 m = 1.09 yd. (approximately)
1 km = 0.62 mi. (approximately)
1 kg = 2.2 lbs. (approximately)

1 in. = 25.4 mm
1 in. = 2.54 cm
1 ft. = 0.30 m (approximately)
1 yd. = 0.91 km (approximately)
1 mi. = 1.6 km (approximately)
1 lb. = 0.45 km (approximately)